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14. ABSTRACT The goal of this project is to develop a primer additive that mimics the self-healing ability of skin by forming a polymer scar across scratches. Designed to work with existing military grade primers, Polyfibroblast consists of microscopic, hollow zinc tubes filled with a moisture-cured polyurethane-urea (MCPU). When scratched, the foaming action of a propellant ejects the resin from the broken tubes and completely fills the crack. No catalysts or curing agents are needed since the polymerization is driven by ambient humidity.					
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# **POLYFIBROBLAST: A SELF-HEALING AND GALVANIC PROTECTION ADDITIVE**

## ***Progress Report #14***

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## 1 Summary

The Camp Lejeune field test took place the week of January 14<sup>th</sup>. The Polyfibroblast primer was applied to the truck bed of an MTRV with no major issues. The application and appearance of the coating was nearly indistinguishable from the unmodified Zn-rich primer, as hoped. We await performance data from the truck bed and witness panels in the coming months.

## 2 Project Goals and Objectives

With the conclusion of the field test, all major project goals have been delivered. The remaining two months will be spent developing quality control measures for the manufacturing process.

## 3 Key Accomplishments

### 3.1 Camp Lejeune Field Test

The truck bed of an MTRV is an ideal platform for demonstrating the self-healing paint due to its size, geometry, and harsh usage conditions. The truck is frequently used to transport munitions and artillery. Typical drills involve the rapid deployment of this equipment, in which the hard, heavy objects are loaded and unloaded from the truck bed in minutes. The truck bed of the MTRV potentially experiences tremendous wear that would leave the underlying steel structure vulnerable to corrosive elements.

All painting was performed by staff from the Corrosion Repair Facility (CRF) at II MEF in Camp Lejeune, NC. Andrew Sheetz, Team Lead for the USMC Corrosion Control Team both designed the test plan and organized the field test with the staff from the CRF facility. PPG Industries, Inc. sent three representatives: Stuart Hellring, Diane Schillinger, and Steve Zawacky. PPG supplied ten gallons of self-healing primer along with various consumable supplies. Also in attendance were observers from LOGCOM, MARCORSYSCOM, II MEF Safety Personnel, the II MEF CRF, Vision Point Systems, NCP Coatings, Southern Fluid Systems, ONRL, and NSWCCD.

Figure 1 shows the application of the Polyfibroblast primer to the left half of the truck bed. The front, top, sides, and underbody were all covered with primer. During application, we observed almost no spurting of the paint, which would have indicated the presence of microcapsule aggregates. PPG has therefore done an excellent job improving the dispersion of the microcapsules into the MIL-P-26915 primer. The dry film build ranged from 7 to 17 mils depending on the location. Due to a shift change, the painting process took slightly longer than expected. The whole process took approximately 4 hours.

Following the application of the topcoat, the painters from the CRF applied a layer of MIL-DTL-53022 CARC primer (Fig. 2). The CARC primer was applied approximately four hours

after the Polyfibroblast primer was applied. Finally, the MIL-DTL-64159 CARC topcoat was applied using an electrocoat process (Fig. 3).



**Figure 1:** Application of the Polyfibroblast primer in the temperature controlled spray booth on January 15, 2013.



**Figure 2:** Both the self-healing primer (left side of truck bed) and the unmodified zinc-rich primer (right half of truck bed) were overcoated with a layer of MIL-DTL-53022 CARC primer. Afterwards, the bottom of the truck was painted with a black undercoat.



**Figure 3:** The final coating was a layer of MIL-DTL-64159 CARC topcoat, which was applied using an electrostatic spray process.

### 3.2 Potential Issues and Lessons Learned

In some cases, the addition of microcapsules causes the MIL-P-26915 primer to gel. The cause of gelling is the fact that the microcapsules frequently carry residual water from the synthesis process that reacts with the polyurethane primer. When completely dried, the microcapsules can be added to the zinc-rich primer with no issues. APL has demonstrated that the microcapsules survive in the primer for at least four months without causing gelation. However, larger batches like those produced by PPG are harder to dry. PPG therefore decided to add the microcapsules onsite rather than mixing them beforehand and shipping the modified zinc-rich primer as a one-component mixture. In future iterations, the Polyfibroblast primer will be a one-component paint, but for this test, it was two.

Unfortunately, the mixing process did not go as smoothly as planned. We were initially told that we would only be given 45 minutes to paint the entire truck bed. With no table or suitable workspace, we attempted to mix the primer on a small cart outside of the spray booth. The first gallon mixed perfectly. However, the second and third batches came out lumpy. Much like when water is added too quickly to flour, the rapid addition of liquid created lumps in the powder that were difficult to remove. This issue did not appear to result from the material, but rather the mixing method. This issue was never seen during preparations and practice runs, because we never practiced a scenario where we were asked to rush. Despite problems mixing some of the paint, it did not affect the field test since we brought ten gallons of paint to the test.

Another lesson learned from this field test is that some of the larger items take longer to paint than expected. Due to the size of the vehicles and shift changes, it is not unusual for the coating process to last several hours. Our pot life was sufficient for this test, but we did not have a large margin for error. Once we improve the drying process for the microcapsules, we will easily exceed the pot life requirements, but it is important to note for future development that the paint should last for at least a full day once it is opened.

Related to the long application time was the long time between the application of the Polyfibroblast primer and the CARC primer. Benchtop experiments showed that the CARC primer should be applied 1-2 hours after the Polyfibroblast primer to obtain optimum adhesion results. But under normal working conditions, that time will be highly variable. For this field test, different portions of the truck bed were allowed different amounts of time to dry. This may result in variations in adhesion between the Polyfibroblast primer and CARC primer. We are confident, though, that the adhesion will still be within the usual specification. Unless unexpected adhesion issues occur in future testing, we do not anticipate any major problems. However, the value of this field test is showing how the real process works. Now that we know that variable drying times are normal, we must prioritize our efforts to ensure that drying time does not impact the adhesion. We suspect that the solvent that we are using is causing certain compounds to bloom at the surface during drying. We therefore hope that the substitution of Solvesso 100 for a different solvent or the removal of solvent altogether will lead to a more robust curing protocol.

The last major issue during the test is perhaps the most concerning. The truck bed was painted in a different order than usual. Normally, one paints the side first, then the top, but in this case, the order was reversed. The result was that there was a large amount of overspray (dry paint powder) on the top of the truck bed. Since this powder would impact the subsequent deposition of CARC primer, it was removed with Scotch Brite. Abrasion is probably the worst thing that one can do to the self-healing primer. Small scratches will prematurely rupture the microcapsules that tend to be enriched at the surface (they float since they have a lower density than the zinc). Once these microcapsules rupture, they are unavailable to heal deep scratches in the paint during service. Another problem is that the liquid that gets released can reduce adhesion. It is an oily substance that is designed to make the steel water repellant. This same effect can reduce the adhesion with subsequent paint coatings that are applied over the top. Time will tell whether the scuffing of the surface will significantly impact the results of the field trial.

## 4 Next Steps

### 4.1 Quality Control

PPG will spend the final two months of the FY12 project implementing quality control measures into their manufacturing process. We will work together to develop protocols and measurements that will help us to quantify various aspects of the microcapsules that will, in turn, help us to qualify the material for future use.